cubic Volterra filtering. The therapy pulse and imaging sequence were interleaved (N = 100 frames), and a video camera was used to visualize the damaged region. A mean bubble cloud image was generated across all treatment sequences and co-registered with the camera image. A ROC curve was formed using binary classification of the mean bubble cloud versus the ablation zone, and the area under the ROC curve was determined. Filtering by quadratic and cubic Volterra filters reduced artifacts significantly [over 20 and 30 dB contrast-to-tissue enhancement ($p < 0.01$), respectively], along with achieving a high area under the ROC curve (0.97). These findings highlight the potential of Volterra filtering for histotripsy guidance.

4:00

1pBAa12. Analysis of gas evolution in the heart, liver, and kidney of turtles presenting with gas embolic pathology based on ultrasonography. Katherine M. Eltz (Biomedical Eng., The Univ. of North Carolina at Chapel Hill, 116 Manning Dr., Chapel Hill, NC 27599, kathmary@live.unc.edu), Jose-Luis Crespo (Res., Fundación Oceanogràfic de la Comunitat Valencia, Valencia, Spain), Arian Azarang (Biomedical Eng., The Univ. of North Carolina at Chapel Hill, Chapel Hill, NC), Emma González (Res., Fundación Oceanogràfic de la Comunitat Valencia, Valencia, Spain), Daniel Garcia (Res., Fundación Oceanogràfic de la Comunitat Valencia, Valencia, Spain), Andreas Fahlman (Kolmården Wildlife Park, Valencia, Spain), and Virginie Papadopoulou (Biomedical Eng., The Univ. of North Carolina at Chapel Hill, Chapel Hill, NC)

Human-caused disturbances of sea turtles can result in them presenting with gas embolic pathology which often leads to severe injury or death. While gas embolism has been previously observed in turtles using MRI and x-ray/CT, as well as ultrasound to a lesser degree, how the distribution of gas evolves in different organs over time, and its possible correlation to outcome, is poorly understood. We hypothesize that ultrasound imaging of the heart, kidney, and liver over time can help differentiate pathology resolution or worsening trajectory and may help refine veterinarians' treatment algorithm in this population. The liver, kidney, and heart of 100 by-caught turtles were imaged, and gas amount in each ultrasound scan was graded on a scale from 0 (no gas) to 5 (gas completely shadowing organ anatomy). Turtles scanned on the boat had higher grades in all organs compared to turtles first scanned at shore which was on average 163 minutes later. Average pixel brightness in the top half of cardiac scans increased with grade as expected, apart from grade 5 likely due shadowing. Ultrasound brightness could become a quantitative metric for veterinarians to determine which turtles need hyperbaric oxygen treatment and which can be released.

MONDAY AFTERNOON, 13 MAY 2024 ROOM 212, 1:00 P.M. TO 4:10 P.M.

Session 1pBAb

Biomedical Acoustics, Physical Acoustics, Signal Processing in Acoustics, and Engineering Acoustics: Ultrasound Brain and Super-Resolution Imaging II

Chengzhi Shi, Cochair
School of Mech. Eng., Georgia Inst. of Technol., 771 Ferst Dr. NW, Atlanta, GA 30332

Fabian Kiessling, Cochair
Exp. Mol. Imaging, RWTH Aachen Univ., Forckenbeckstrasse 55, n.a., Aachen 52074, Germany

Invited Papers

1:00

1pBAb1. Deep-brain imaging with 3D integrated photoacoustic tomography and ultrasound localization microscopy. Junjie Yao (Duke Univ., 100 Sci. Dr., Hudson Hall Annex 261, Durham, NC 27708, junjie.yao@duke.edu)

Photoacoustic computed tomography (PACT) is a proven technology for imaging hemodynamics in deep brain of small animal models. PACT is inherently compatible with ultrasound (US) imaging, providing complementary contrast mechanisms. While PACT can quantify the brain's oxygen saturation of hemoglobin (sO_2), US imaging can probe the blood flow based on the Doppler effect. Furthermore, by tracking gas-filled microbubbles, ultrasound localization microscopy (ULM) can map the blood flow velocity with sub-diffraction spatial resolution. In this work, we present a 3D deep-brain imaging system that seamlessly integrates PACT and ULM into a single device, 3D-PAULM. Using a low ultrasound frequency of 4 MHz, 3D-PAULM is capable of imaging the whole-brain hemodynamic functions with intact scalp and skull in a totally non-invasive manner. Using 3D-PAULM, we studied the mouse brain functions with ischemic stroke. Multi-spectral PACT, US B-mode imaging, microbubble-enhanced power Doppler (PD), and ULM were performed on the same mouse brain with intrinsic image co-registration. From the multi-modality measurements, we future quantified blood perfusion, sO_2, vessel density, and flow velocity of the mouse brain, showing stroke-induced ischemia, hypoxia, and reduced blood flow. We expect that 3D-PAULM can find broad applications in studying deep brain functions on small animal models.

1:20

1pBAb2. Parametric study of blind-label acoustic subwavelength imaging. Jinuan Lin (Elec. and Comput. Eng., Univ. of Wisconsin-Madison, Madison, WI) and Chu Ma (Elec. and Comput. Eng., Univ. of Wisconsin-Madison, 1415 Eng. Dr., Rm. 3436, Madison, WI 53706, chu.ma@wisc.edu)

There is a long-existing tradeoff between the imaging resolution and the penetration depth in imaging systems caused by the diffraction limit. We developed a "blind label" approach to tackle this problem, which significantly improves the practicality of acoustic subwavelength imaging in biomedical ultrasound imaging, non-destructive testing, and other acoustic sensing and communication applications. The "blind labels" in our system refer to randomly distributed acoustic scatterers with deep-subwavelength sizes whose exact locations and trajectories are not necessary information in image reconstruction. Our imaging framework is composed of two parts: (1) spatial mixing: a physical process that converts the originally evanescent components in the scattered waves from the object to propagating components that can reach the far-field detector and (2) computational reconstruction. In this talk, we will mainly report our quantitative investigation of the system parameters' impact on the performance of the blind-label subwavelength imaging system, providing guidance to future system setups in various applications.

1:40

1pBAb3. Wearable ultrasound technology. Sheng Xu (Nanoengineering, UC San Diego, 9500 Gilman Dr. Mail Code 0448, SME Bldg., Rm. 343J, La Jolla, CA 92093, shengxu@ucsd.edu)

The use of wearable electronic devices that can acquire vital signs from the human body noninvasively and continuously is a significant trend for healthcare. The combination of materials design and advanced microfabrication techniques enables the integration of various components and devices onto a wearable platform, resulting in functional systems with minimal limitations on the human body. Physiological signals from deep tissues are particularly valuable as they have a stronger and faster correlation with the internal events within the body compared to signals obtained from the surface of the skin. In this presentation, I will demonstrate a soft ultrasonic technology that can noninvasively and continuously acquire dynamic information about deep tissues and central organs. I will also showcase examples of this technology's use in recording blood pressure and flow waveforms in central vessels, monitoring cardiac chamber activities, and measuring core body temperatures. The soft ultrasonic technology presented represents a platform with vast potential for applications in consumer electronics, defense medicine, and clinical practices.

2:00

1pBAb4. Reconstruction methods for super-resolution imaging with PSF modulation. Jian-yu Lu (Bioengineering, The Univ. of Toledo, 2801 West Bancroft St., Toledo, OH 43606, jian-yu.lu@ieee.org)

Recently, a super-resolution imaging method called the PSF (point spread function) modulation method was developed (Lu, IEEE TUFFC 2024). In this method, the amplitude, phase, or both of the PSF of a linear shift-invariant (LSI) imaging system is modulated so that the modulated PSF has a higher spatial frequency than that of the original PSF to reconstruct super-resolution images. The modulator can be produced and manipulated remotely by methods such as radiation force or it can be a physical particle such as micro- or nanoparticle manipulated by an external force such as electrical and electromagnetic force. In principle, the super-resolution imaging method can be applied to any LSI imaging system, such as ultrasound, optical, photoacoustic, electromagnetic, underwater, nondestructive evaluation (NDE), and magnetic resonance imaging (MRI) system. These include pulse-echo ultrasound imaging, transmission imaging, wave source/field imaging, acoustical camera, and optical bright-field microscope. To optimize the quality of the images, methods for the reconstruction of pulse-echo and wave source/field super-resolution images are studied and the results will be presented. These methods include the uses of an analytic envelope of radio-frequency (RF) signals with and without windowing, "I" (in-phase) and "Q" (quadrature) signals, and the DC (direct current) component removal.

2:20–2:35 Break

Contributed Papers

2:35

1pBAb5. Improving photoacoustic imaging through the skull using deep learning: a numerical study. Matthew J. Olmstead (Acoust., Penn State Univ., 201 Appl. Sci. Bldg., University Park, PA 16802, mjolmstead@mac.com), Yu-tong Wang (Acoust., Penn State Univ., University Park, PA), Zixuan Tian (Elec. and Comput. Eng., Univ. of Illinois, Urbana Champaign, Urbana, IL), Hyungjoo Park (Acoust., Penn State Univ., University Park, PA), Aiguo Han (Biomedical Eng. and Mech., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA), and Yun Jing (Acoust., Penn State Univ., State College, PA)

Photoacoustic computed tomography (PACT) has recently emerged as an attractive imaging modality for functional brain imaging due to its rich optical absorption contrast, high spatial and temporal resolutions, and relatively deep penetration. However, a major hurdle in using PACT for the human brain is distortion of the signal due to the skull, which negatively affects the quality of the images. In this project, we aimed to improve transcranial PACT using a U-Net architecture that can minimize distortion from the skull. This numerical study utilized a large collection of blood vessel images obtained from an online database and a computed tomography (CT) scan of an *ex vivo* human skull. The synthetic photoacoustic radiofrequency data were generated using the open-source wave solver *k*-Wave. Comparing the images generated by deep learning with the ground truth images, we achieved an average structural similarity index of 0.874 and an average peak signal-to-noise ratio of 17.92 dB.